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Title: $^{239}\text{Pu}(n,f)$ Neutron Multiplicity Evaluation with CGMF-Very First Release Candidate.

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²³⁹Pu(n,f) Neutron Multiplicity Evaluation with CGMF-Very First Release Candidate.

D. Neudecker & A. Lovell

June 28-July13, 2021

$^{239}\text{Pu}(n,f)$ $\bar{\nu}$ evaluated with CGMF from $E_{\text{inc}} = 0.1\text{-}20$ MeV.

Changes compared to VIII.0:

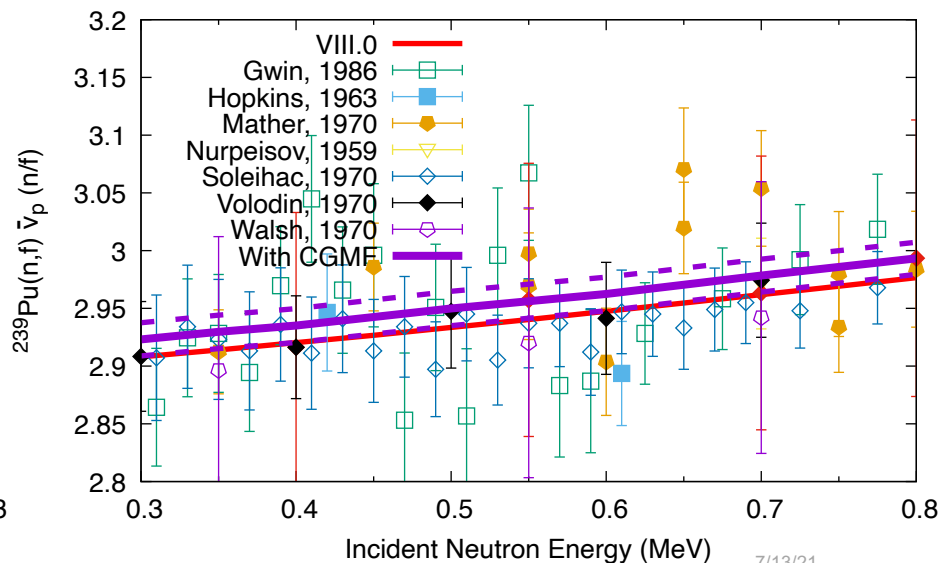
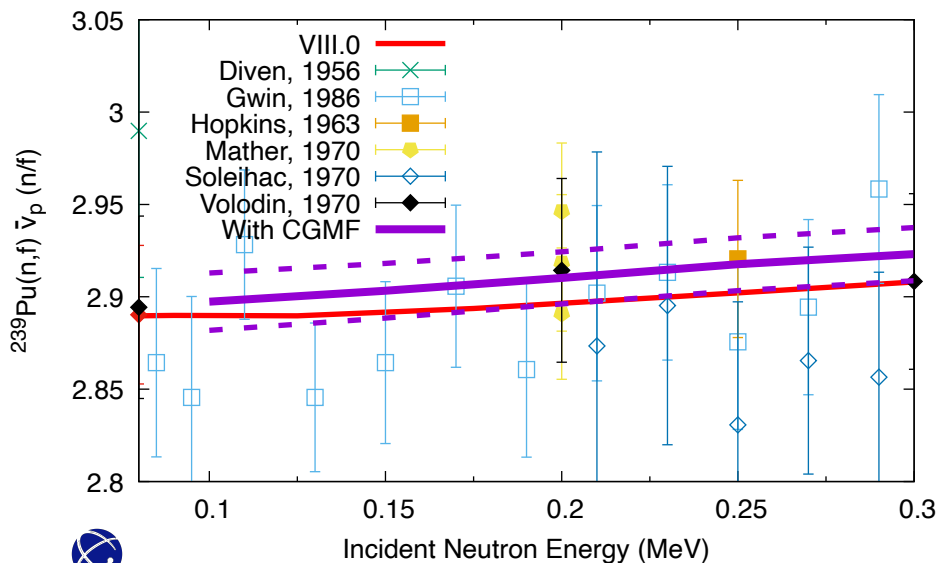
- Prior: CGMF model included via Kalman and sensitivities of CGMF model parameters to $\bar{\nu}$ (Amy).
- Evaluation technique: Kalman including correction for PPP (Denise).
- Experimental data (Denise):
 - Nearly all data that Phil took into account (I rejected: Huanqiao, Johnstone, Leroy, Nesterov, Smirenkin),
 - New UQ for all experimental data,
 - Marini,
 - No correlations between unc. of different exp., except for Cf-252(sf) $\bar{\nu}$ uncertainty cross-correlating all uncertainties.



$^{239}\text{Pu}(n,f)$ nu-bar $E_{\text{inc}} = 0.1\text{-}0.8$ MeV: higher than VIII.0.

The new evaluation is higher than ENDF/B-VIII.0. The reasons for that are:

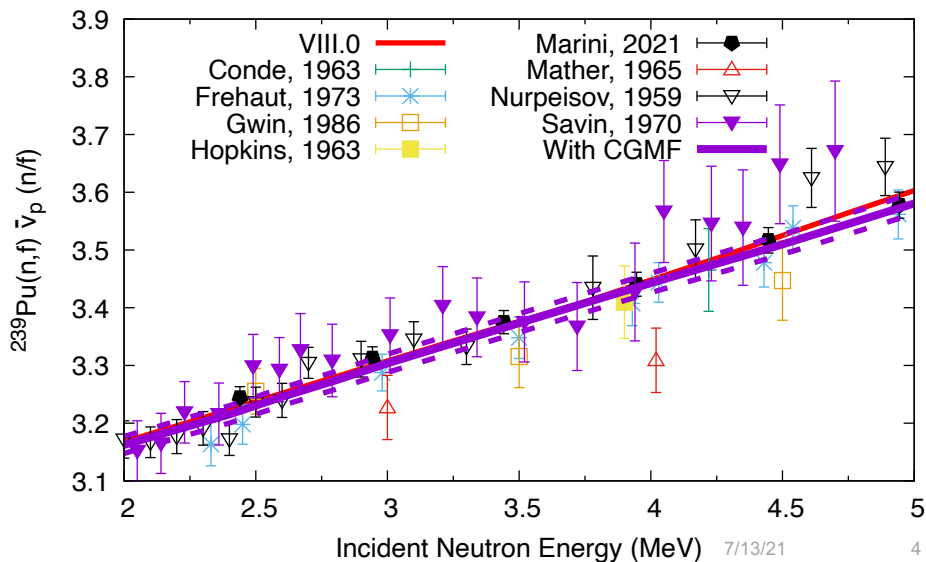
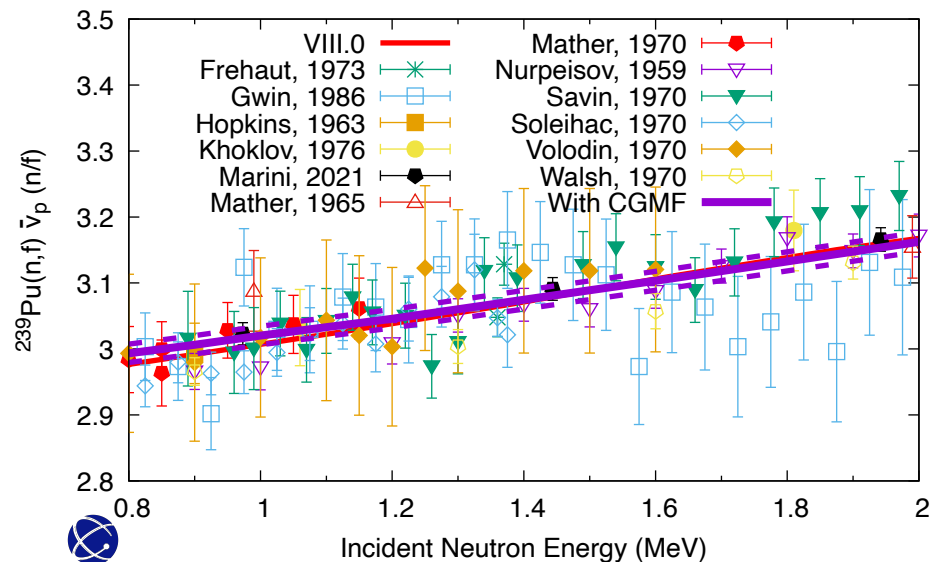
- Model stiffness below 300 keV,
- New UQ, rejecting data (Huanqiao, Nesterov) and including Marini data ≥ 1 MeV.



$^{239}\text{Pu}(n,f)$ nu-bar $E_{\text{inc}} = 0.8\text{-}5$ MeV: very similar to VIII.0.

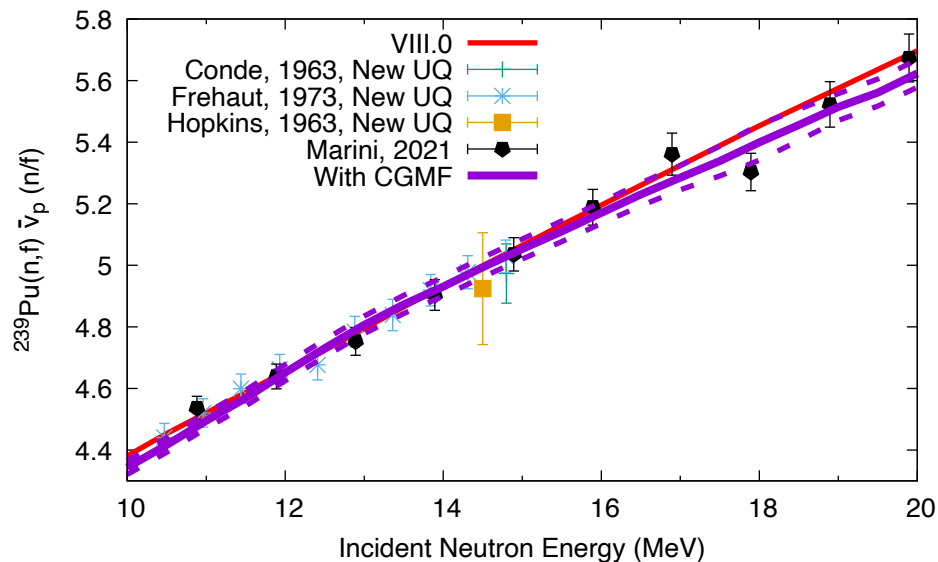
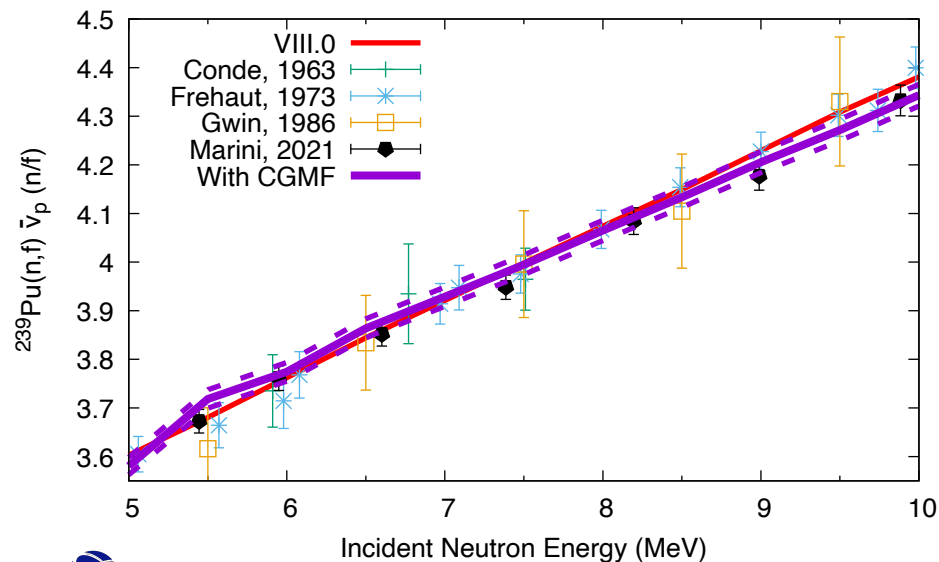
Reasons for changes:

- From 800 keV-5 MeV: Marini, new exp. UQ and rejecting data lead to changes.
- Changes are in the $\pm 0.5\%$ range.



$^{239}\text{Pu}(n,f)$ nu-bar $E_{\text{inc}} = 5\text{-}20$ MeV: multiple-chance fission seen.

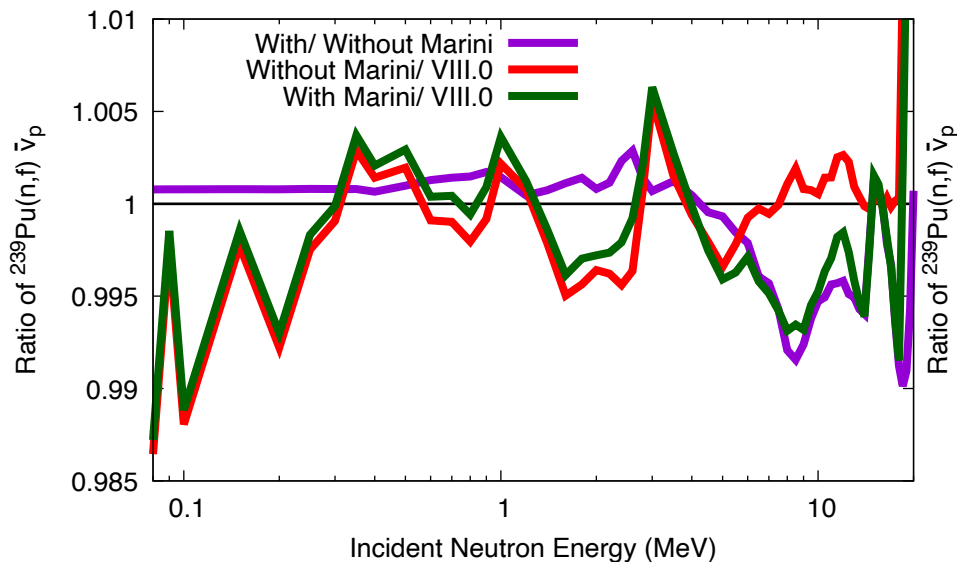
- Rise at 5.5 MeV: coming from CGMF modeling.
- Decrease from 8-10 MeV: Marini and CGMF model
- Decrease from 16-20 MeV: Marini.



$^{239}\text{Pu}(n,f)$ nu-bar $E_{\text{inc}} = 0.1\text{-}20$ MeV. Summary of changes.

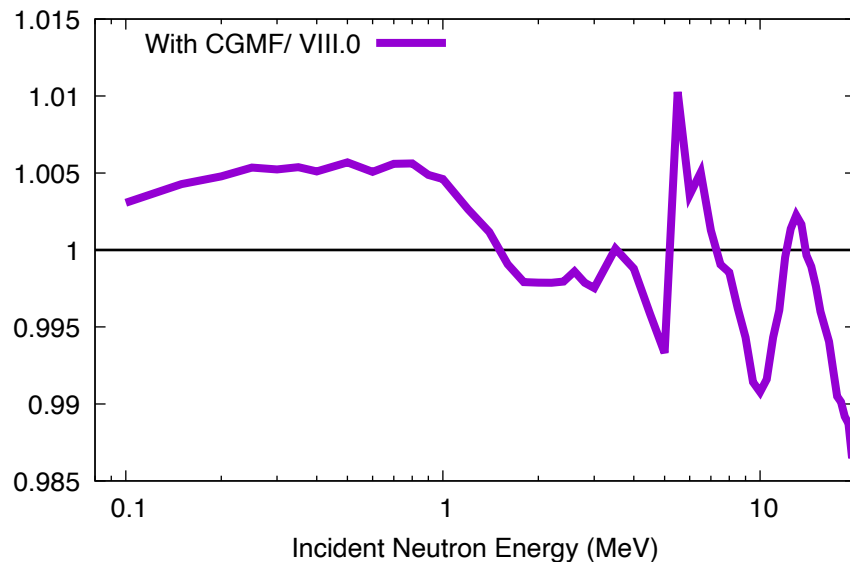
First step:

With/ Without Marini ... evaluation
with only experimental data.

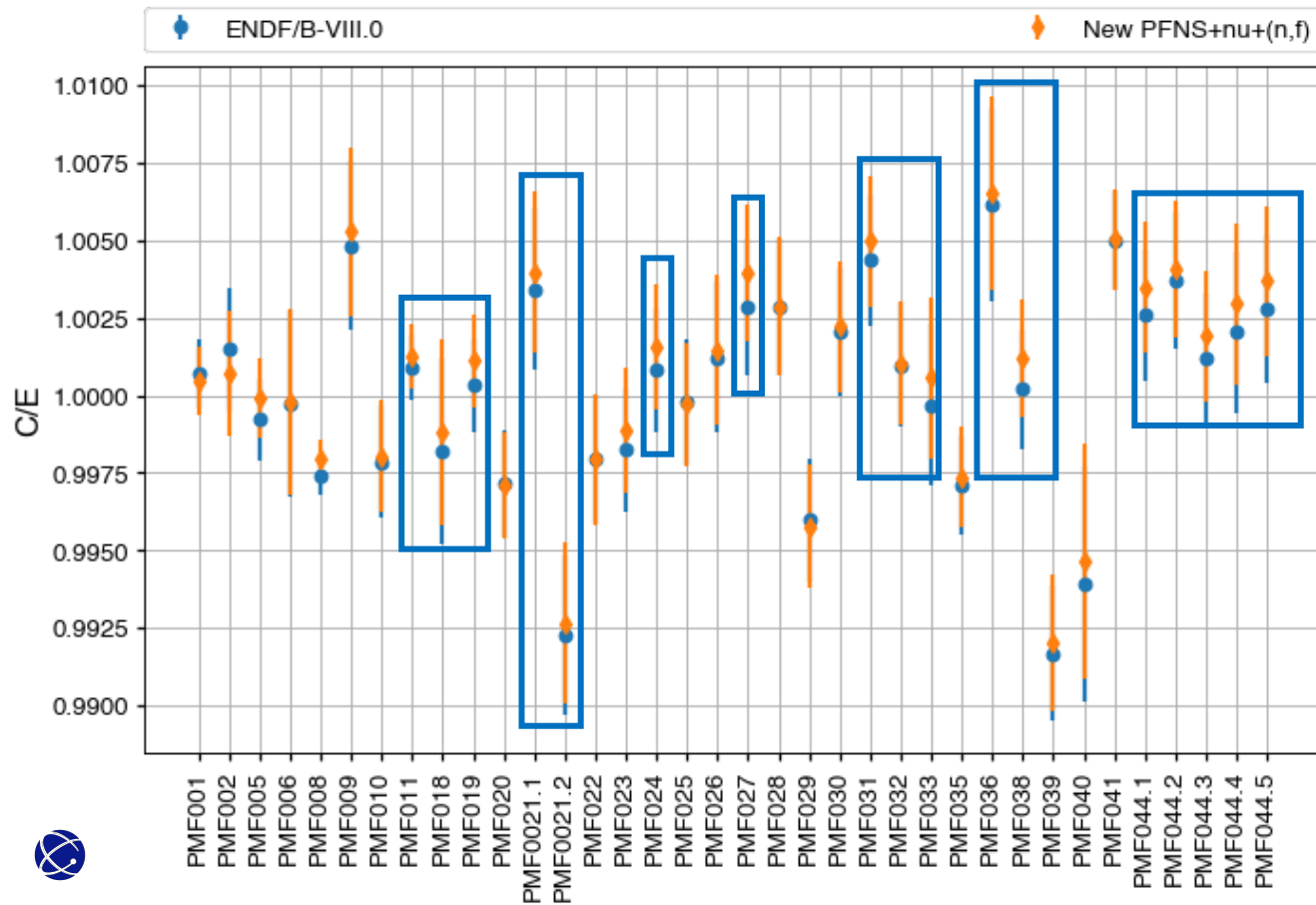


Second step:

Changes if CGMF model is added.



Benchmarking with k_{eff} of PU-MET-FAST assemblies:



Mean bias for
VIII.0:

18 pcm

Mean bias for new
PFNS+nu+(n,f):

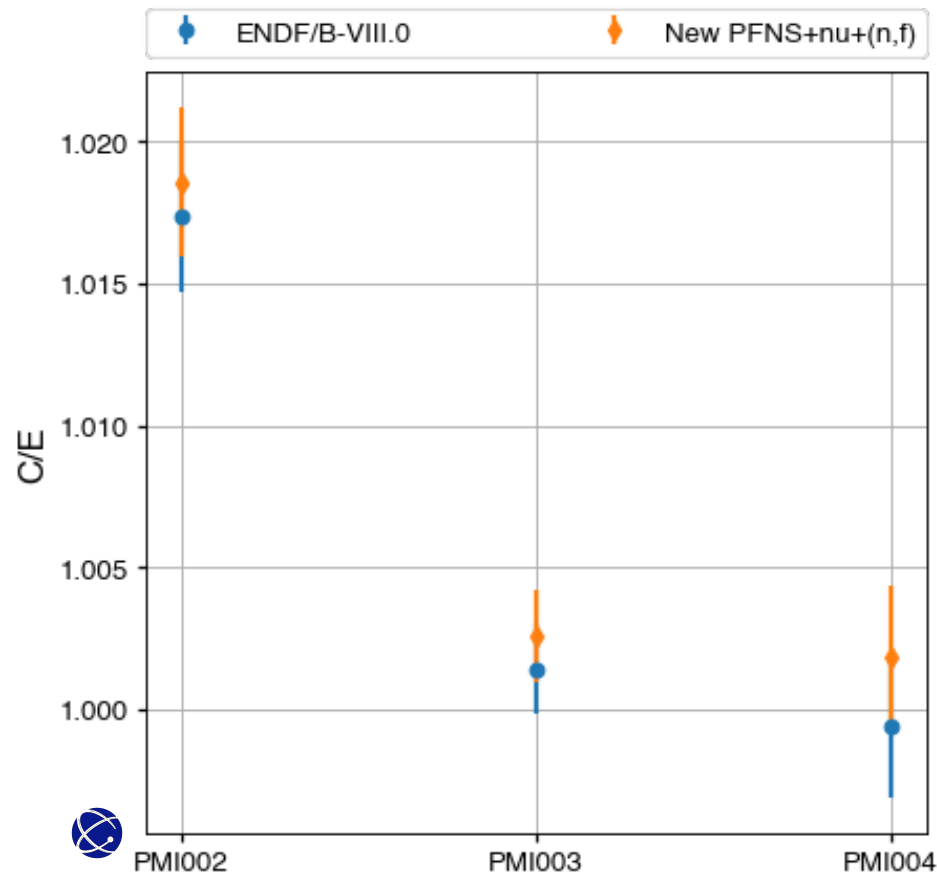
58 pcm

The faster the k_{eff}
spectrum, the
better C/E.

Softer spectra ->
worse C/E.



Benchmarking with k_{eff} of PU-MET-INT assemblies:



Mean bias for VIII.0: 601 pcm

Mean bias for new PFNS+nu+(n,f): 767 pcm

The faster the k_{eff} spectrum, the better C/E. Softer spectra -> worse C/E. -> seen as well for PMI which are not well-known.

Should we tweak nu-bar at lower E_{inc} ? If yes, where? -> I would propose a slight tweak from 0.1-0.3 MeV?



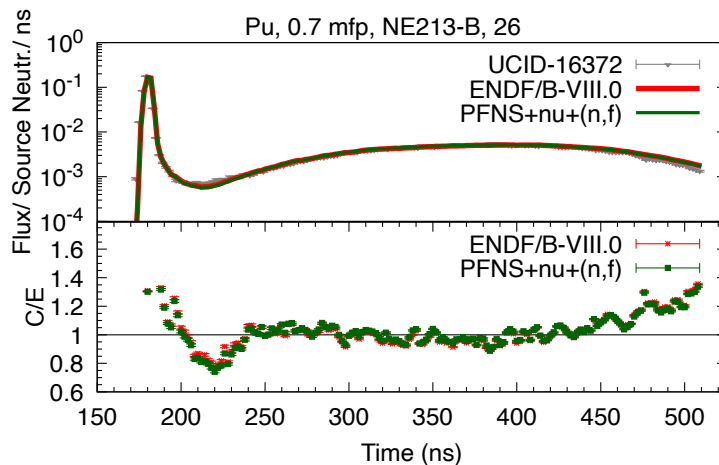
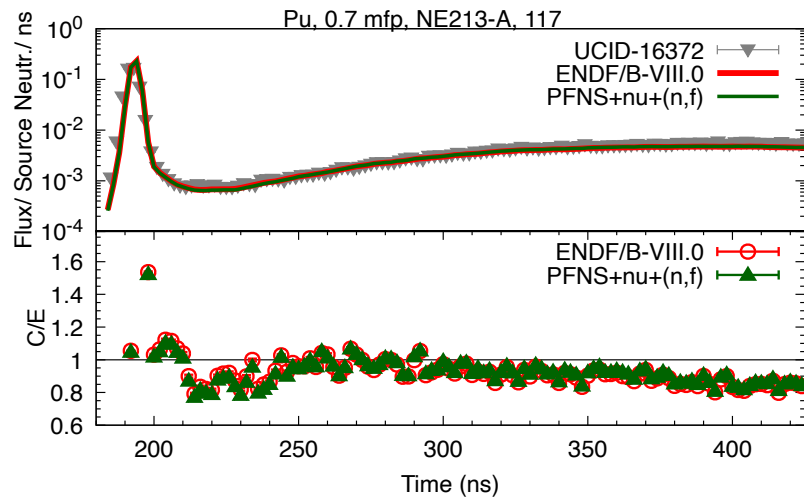
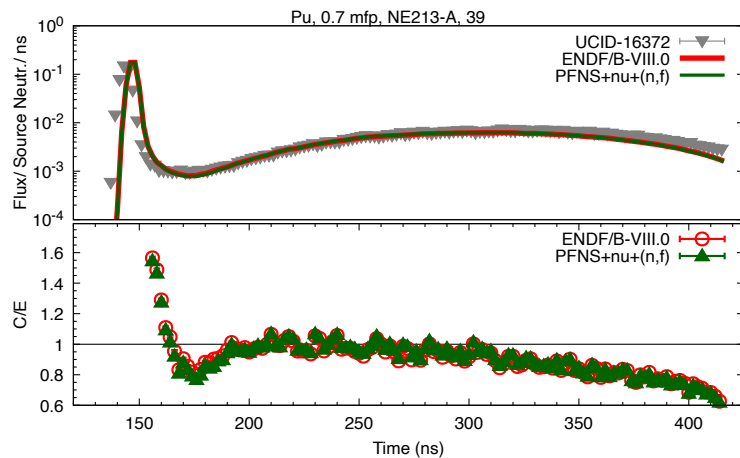
Benchmarking (green: change within VIII.0+ MC unc., red: change outside of VIII.0+MC unc., unc. on last digit).

Jezebel	Keff	Pu9(n,2n)/(n,f)	Pu9(n,g)/(n,f)	U8/U5(n,f)	Np/U5(n,f)	U3/U5(n,f)	Pu9/U5(n,f)
VIII.0	1.00069(1)	0.00230(5)	0.0345(2)	0.212(1)	0.9768(5)	1.566(7)	1.427(6)
VIII.0+new: PFNS, (n,f)+nu	1.00047(1)	0.00224(5)	0.0355(2)	0.209(1)	0.9662(5)	1.566(7)	1.423(6)

Flattop-Pu	Keff	Pu9(n,2n)/(n,f)	Pu9(n,g)/(n,f)	U8/U5(n,f)	Np/U5(n,f)
VIII.0	0.99971(1)	0.00197(4)	0.0455(1)	0.1800(9)	0.8591(4)
VIII.0+new: PFNS, (n,f)+nu	0.99981(1)	0.00193(4)	0.0464(1)	0.1774(9)	0.8497(4)



Benchmarking Pulsed Sphere: little change.



We have a release candidate of a $^{239}\text{Pu}(\text{n},\text{f})$ nu-bar evaluation

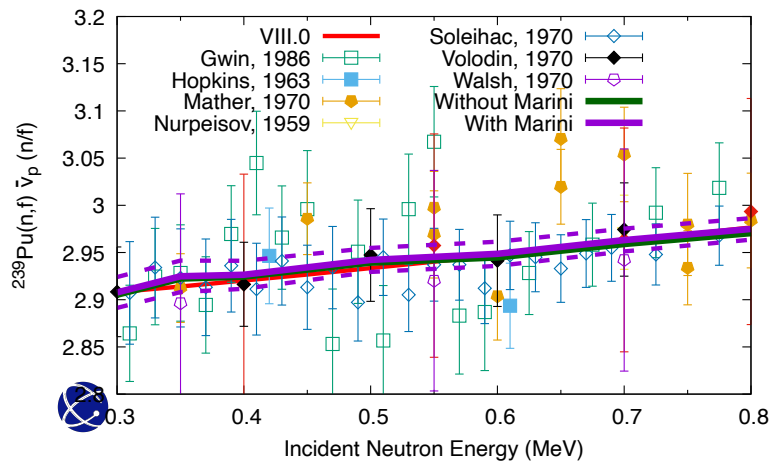
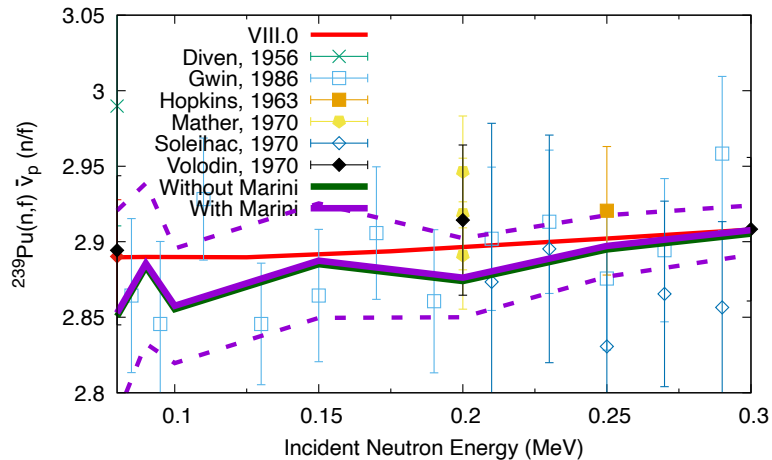
- First validation seems promising.
- We need to further validate these new evaluated data (e.g., PSTs, beta-eff).
- We need to look at continuity.
- U-235(n,f) nu-bar in progress.

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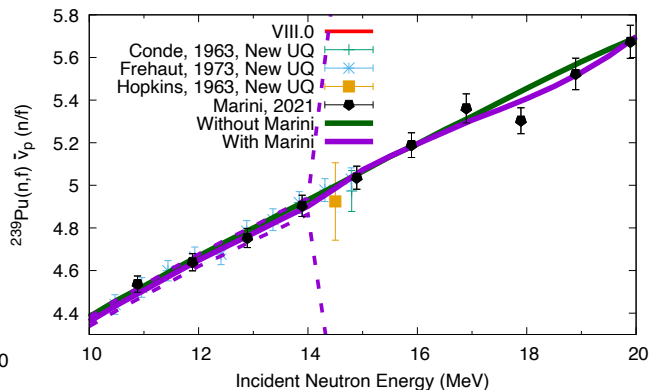
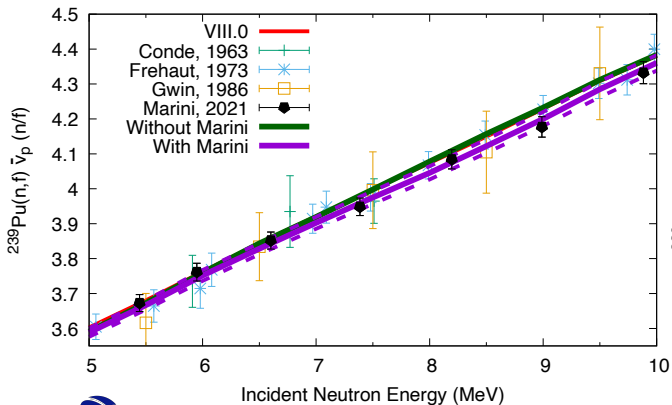
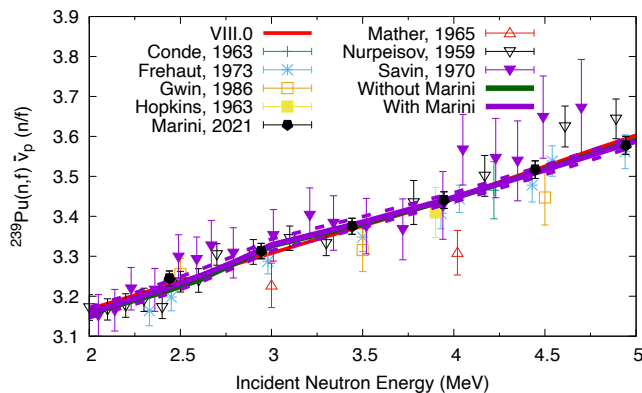
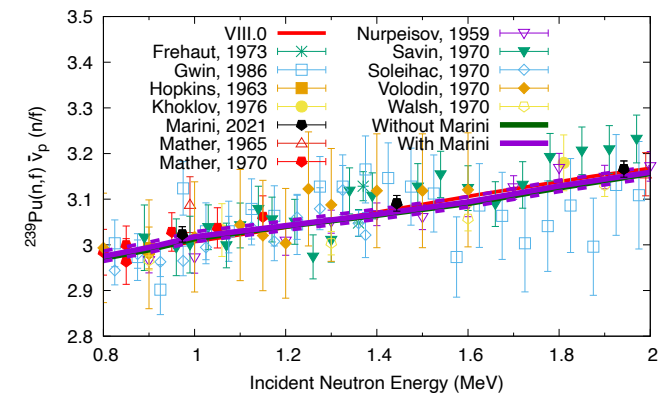
$^{239}\text{Pu}(n,f)$ nu-bar: evaluation with Marini and without Marini data. Only experimental data are used for the evaluation.



Comments:

- Evaluation below 200 keV has many kinks and follow scarce experimental data. The one experimental data set defining the evaluation has very high statistical uncertainties -> this is not a physics behavior.
- Reasonably smooth below 300 keV AFTER smoothing.
- Rejected Huanqiao and Nesterov in energy range 300 keV to 1 MeV.
- Marini's first data point at 1 MeV up to over 20 MeV.

$^{239}\text{Pu}(n,f)$ nu-bar: evaluation with Marini and without Marini data. Only experimental data are used for the evaluation.



Comments:

- 2nd c.f.: it is a bit visible in Marini data -> you see a slight increase at 6 MeV compared to a linear slope and then you go slightly below a linear slope for 8 MeV.

